WORK VEHICLE HYDRAULIC SYSTEM

Field of the Invention

[0001] This invention relates generally to off-road work vehicles. In particular, it relates to hydraulic systems for work vehicles such as loader-backhoes. Even more particularly it relates to devices and methods for loading and unloading the hydraulic circuits of those vehicles.

Background of the Invention

[0002] Off-highway work vehicles such as loader-backhoes utilize a variety of hydraulic system architectures. One common arrangement is called an "open center" architecture. In a typically open center systems, a constant displacement pump such as a simple gear pump is used as a primary source of hydraulic fluid for the various hydraulic devices in the system. The pump provides a constant flow rate of hydraulic fluid through the system that does not vary with time. The control valves function by restricting this hydraulic fluid flow through the pump and providing an alternative path into the actuator to be moved. The pump responsively raises the pressure in its outlet line (i.e. the main hydraulic supply line) sufficient to maintain a constant flow rate through the pump. In an open center system, generally speaking, the flow rate through the pump is constant and the load on the pump and engine varies with changing head pressure.

[0003] In another common arrangement, called a "closed center" architecture, a variable displacement pump (such as a de-stroking piston pump) is provided that is configured to maintain a relatively constant output pressure regardless of the flow rate over time. The various control valves function by connecting the devices they control to

the output of the pump. When the control valves provide this alternative flow path, the output pressure tends to drop and the control circuit for the pump compensates by increasing the specific displacement of the pump. When the specific displacement is increased, the pressure is restored to its design output pressure. When the operator closes the valve that conducts fluid to the desired device, the pressure increases in the system and the control circuitry for the hydraulic pump responsively reduces the specific displacement of the pump (i.e. the pump is "destroked"). In a closed center system, generally speaking, the pressure provided by the pump is constant and the flow rate is varied as necessary to maintain a constant head pressure.

[0004] Some systems are hybrids of both open center and closed center components. In these systems, some control valves are configured to operate as open center valves and some control valves are configured to operate as closed center valves. In these hybrid systems, the pump is an open center (i.e. constant displacement) pump. This mandates that one modify the closed center valves for use in an otherwise open center system. The closed center valves must be coupled to the hydraulic supply at a point downstream from the open center components in order to operate properly.

[0005] The modifications in hybrid systems include an inlet compensator at the inlet of the closed center valves that directs hydraulic fluid either to the closed center function when the closed center valves are selected, or directs it to the tank when the open center valves are used. The inlet compensator requires a constant pressure differential be established to work correctly but increases average working pressure, higher neutral standby pressures, more component complexity/cost to make the system perform correctly, increased fuel consumption, etc.

[0006] What is needed is a system for directing fluid flow to both open center and closed center components that reduces the losses in current subsystems. What is also needed is a system that eliminates the need for an inlet compensator. It is an object of this invention to provide such a system.

Summary of the Invention

[0007] In accordance with a first embodiment of the invention, a hydraulic system for a work vehicle is provided having a first hydraulic pump configured to generate a flow of hydraulic fluid; a priority valve in fluid communication with the pump, the priority valve being configured to distribute the flow to a first outlet and to a second outlet; a plurality of open center hydraulic valves coupled to the first outlet; and a plurality of closed center hydraulic valves coupled to the second outlet.

[0008] The first hydraulic pump may be a fixed displacement gear pump, and the priority valve may be responsive to a load on the plurality of closed center valves. The plurality of closed center valves may include at least one valve selected from the group including a boom swing actuator control valve, a boom cylinder control valve, a dipper cylinder control valve, and a bucket cylinder control valve. The plurality of open center valves may include at least one valve selected from the group including a loader bucket cylinder valve and a loader arm cylinder valve. The system may further include a second hydraulic pump coupled to and driving the plurality of closed center hydraulic valves. The second pump may be responsive to some loads that control the priority valve and independent of other loads that control the priority valve. There may be no inlet compensator in fluid communication with and disposed between the plurality of closed center hydraulic valves and the first pump. The system may also include a second fixed displacement hydraulic pump disposed to provide the plurality of closed center valves with hydraulic fluid. The system may further include a reloader valve coupled to and between the second hydraulic pump and the plurality of closed center valves, and the rebader valve may be responsive to a load signal on a load signal line coupled to the plurality of closed center valves.

[0009] In accordance with a second embodiment of the invention, a hydraulic system for a work vehicle is provided that includes an engine; a first hydraulic pump driven by the engine and configured to generate a flow of hydraulic fluid; a priority valve in fluid communication with the pump, the priority valve being configured to distribute the flow to a priority outlet and to a secondary outlet; a plurality of open center hydraulic valves coupled to one of the priority and secondary outlets; a plurality of closed center

hydraulic valves coupled to another of the primary and secondary outlets; and a second pump driven by the engine and configured to provide hydraulic fluid to the plurality of closed center valves.

[0010] The first and second hydraulic pumps may be fixed displacement gear pumps. The plurality of closed center valves may include at least one valve selected from the group comprising a boom swing actuator control valve, a boom actuator control valve, a dipper actuator control valve, and a bucket actuator control valve. The plurality of open center valves may include at least one valve selected from the group comprising a loader bucket actuator valve and a loader arm actuator valve. The second hydraulic pump may be coupled to and may drive the plurality of closed center hydraulic valves. The second hydraulic pump may be configured to be responsive to at least one load that controls the priority valve. The second hydraulic pump may be configured to be independent of at least one load that controls the priority valve. The system may have no inlet compensator in fluid communication with and disposed between the plurality of closed center hydraulic valves and the first pump. The system may also include a reloader valve coupled to and between the second hydraulic pump and the plurality of closed center valves, the reloader valve being responsive to a load signal on a load signal line coupled to the plurality of closed center valves.

Brief Description of the Drawings

[0011] **FIGURE 1** shows a prior art work vehicle hydraulic system in which a priority valve supplies hydraulic fluid to open center control valves, then to an inlet compensator and bank of closed center control valves.

[0012] **FIGURE 2** illustrates a work vehicle hydraulic system in accordance with the present invention, in which both closed center and open center valves are served by a priority valve coupled to a first hydraulic pump. The system includes a second hydraulic pump under independent load control.

[0013] **FIGURE 3** illustrates a second work vehicle hydraulic system in accordance with the present invention, in which both closed center and open center valves are served by a priority valve coupled to a first hydraulic pump. This system also includes a

second hydraulic pump under independent load control.

Detailed Description of the Preferred Embodiments

[0014] **FIGURE 1** shows a prior art hydraulic control system **100** for a work vehicle. In this example, the vehicle is a loader-backhoe. The circuit includes an engine **102** that drives hydraulic pumps **104** and **105**.

[0015] Pumps **104** and **105** are constant displacement gear pumps. Pump **104** supplies hydraulic fluid to a priority valve **106**. The priority valve splits the flow on a priority basis between the priority or primary steering circuit **108** on the one hand and the secondary circuit that includes open center valves **110**, closed center valves **112** and inlet compensator **114**.

[0016] Until a load is present on the steering circuit, the priority valve directs fluid to the open center loader valves **110** and then through the open center valves **110** to the closed center backhoe valves **112** through inlet compensator **114**. Whenever a load appears on the steering circuit, however, priority valve **106** directs all necessary flow to the steering circuit. Pump **105** is always coupled to the closed center valves to provide them with fluid.

[0017] In the prior art hybrid designs such as the one shown in **FIGURE 1**, providing a desired working pressure at the closed center valves requires a pressure ten to fifteen percent higher at the pump itself. The ten to fifteen percent higher pressure represents frictional losses in the hydraulic components–engine power that is converted to waste heat. By contrast, in a pure open center system without the inlet compensator, frictional losses would be reduced significantly to just a few percent of the working pressure.

[0018] By coupling both the open center and the closed center valves to the priority valve in parallel, rather than in series (from the pump to the open center valves and then in series to the closed center valves, as shown in **FIGURES 2** and **3** of the preferred embodiment) these frictional losses can be substantially reduced. The engine horsepower previously dissipated in producing these losses can again be made available to the operator of the vehicle for productive use.

[0019] **FIGURES 2** and **3** disclose a hydraulic system **200** for a work vehicle (in this

example a loader backhoe) having a first pump **202**, a second pump **204**, an engine **206**, a priority valve **208**, open center loader control valves and associated actuators **210** (which include a loader bucket control valve and actuator and a loader arm control valve and actuator), hydraulic return tank or reservoir **212**, closed center backhoe control valves and actuators **214** (which include a boom swing control valve and actuator, a boom control valve and actuator, a dipper control valve and actuator, and a bucket control valve and actuator), steering valves and actuators **218**, reloader valve **222**, and pressure relief valve **224**.

[0020] Engine **206** drives first and second pumps **202** and **204**. These pumps are fixed displacement gear pumps. Pump **202** pumps fluid to priority valve **208**, which distributes the fluid two different ways based upon the load signal (LS) it receives on load signal line **226**; when priority valve **208** senses an increased load on signal line **226**, it distributes more fluid to its primary (priority) port **228** and less fluid it to its secondary port **230**, and vice versa. Pump **204** supplements the hydraulic fluid provided by pump **202** to closed center valves and actuators **214**. Pump **204** provides hydraulic fluid to reloader valve **222**. Reloader valve **222**, in turn, supplies hydraulic fluid to closed center valves and actuators **214** on supply line **232**. In **FIGURE 2** when the load signal on line **234** indicates a load on a first, lower subset **240** of closed center backhoe valves and actuators **214** (but not the second, upper subset **238** of them), and in **FIGURE 3** when the load signal on line **234** indicates a load on the entire group of closed center backhoe valves and actuators **214**, then reloader valve **222** opens to conduct fluid to those valves and actuators **240 (FIG 2)** and **214 (FIG 3)**. When the load signal on line **234** indicates no load or minimal load, reloader valve **222** is configured to stop supplying fluid to closed center valves and actuators **240 (FIG. 2)**, and **214 (FIG. 3)** and the fluid flow from pump **204** is dumped back to tank **212** via pressure relief valve **224**.

[0021] **FIGURES 2** and **3** differ in one respect only: the way the load signal is applied to priority valve **208** and reloader valve **222**. In both **FIGURES 2** and **3**, a check valve **236** is disposed between load signal line **226** and load signal line **234**. Check valve **236** serves to isolate the two load signal lines **226, 234** in certain modes of operation,

making them independent and making reloader valve **222** and priority valve **208** respond differently to changes in load.

[0022] In the arrangement of **FIGURE 2**, check valve **236** is located between the two subsets **238, 240** of closed center backhoe valves and actuators **214**. One subset **238** of the closed center boom swing control valve and actuators **214** is fluidly coupled to load signal line **226** which is above valve **236**. Subset **238** includes the boom swing valve and actuators. The second subset **240** of the closed center boom swing control valve and actuators **214** is fluidly coupled to load signal line **234**, which is below valve **236**. Subset **240** includes the boom, the dipper, and the bucket control valves and actuators.

[0023] Whenever the load signal increases for the remaining backhoe valves and actuators **240**, it is communicated both to load signal line **234** directly, and to load signal line **226** which extends from valves and actuators **214** across the top of **FIGURES 2** and **3** to the steering valves and actuators **218** and then to priority valve **208** to which it is coupled. This connection to both of load signal lines **226** and **234** increases hydraulic fluid flow from pumps **202** and **204** to valves and actuators **240**.

[0024] Whenever the load signal increases for the steering valves and actuators **218**, or for closed center boom swing valve and actuators **238**, the increased load signal only affects load signal line **226** and pump **202**. The increased load signal does not affect load signal line **234**, since check valve **236** prevents the signal from reaching load signal line **234**.

[0025] As a result, changes in steering actuator loads or boom swing actuator loads are communicated (i.e. fed back) only to pump **202** through load signal line **226**, which controls priority valve **208**. Changes in boom cylinder, dipper cylinder and bucket cylinder loads are communicated (i.e. fed back) to both pump **202** (through the load signal line **226**, which goes to priority valve **208**, which in turn controls the flow direction of pump **202**) and pump **204** (through load signal line **234**, which goes to reloader valve **222**, which controls the flow direction of flow from pump **204**). Thus there are some loads connected to the closed center valves that pump **204** is independent of and not affected by, and there are some loads connected to closed center valves that pump

204 is responsive to. In one mode, pump 204 is independent of the load placed on pump 202 and of the operation of pump 202, and in another mode of operation, pump 204 operates in conjunction with pump 202 and is equally responsive to the loads placed on pump 202.

[0026] In the arrangement of FIGURE 3, all the backhoe valves and actuators 214 are on one side of check valve 236.

[0027] In FIGURE 3, whenever the load signal increases for any closed center backhoe valve and actuator 214 it is communicated both to load signal line 234 directly, and to load signal line 226 through check valve 236. This increases hydraulic fluid flow from pumps 202 and 204 to all the closed center valves and actuators 214.

[0028] Unlike the embodiment of FIGURE 2, none of the closed center backhoe valves and actuators are isolated from pump 202 as the boom swing valve and actuators were in FIGURE 2. Any load on any of the closed center backhoe valves and actuators will be communicated to pump 202 as well as to pump 204, since valve 236 does not block changes in backhoe loads from being applied to both load signal line 226 (to priority valve 208) and load signal line 234 (to reloader valve 222). Since all the closed center backhoe loads, including the boom swing valves and actuators, are coupled to load signal line 234 below check valve 236, they action both load signal lines 226 and 234, and therefore control both reloader valve 222 and priority valve 208.

[0029] Whenever the load signal on line 226 (FIG. 3) increases for the steering valves and actuators 218, as in FIGURE 2, the increased load signal only affects load signal line 226 and pump 202. The increased signal does not affect load signal line 234, since check valve 236 prevents the signal from reaching load signal line 234. As a result, changes in steering cylinder loads are communicated only to pump 202 and not to pump 204.

[0030] From the foregoing, it will be observed that numerous modifications and variations can be effected without departing from the true spirit and scope of the novel concept of the present invention. It will be appreciated that the present disclosure is intended as an exemplification of the invention, and is not intended to limit the invention to the specific embodiment illustrated. The disclosure is intended to cover by the

appended claims all such modifications as fall within the scope of the claims.

[0031] For example, the hydraulic actuators disclosed herein may be rotary devices such as hydraulic motors. They may also be linear devices such as hydraulic cylinders, both double-acting and single-acting.